ADMINISTRATIVE INFORMATION

1. **Project Name:** Development of Functionally Graded Material for Manufacturing Tools and Dies and Industrial Processing Equipment.

2. **Lead Organization:** Carpenter Powder Products
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3. **Principal Investigator:** Louis W Lherbier
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4. **Project Partners:** Pacific Northwest National Laboratory, Darrell Herling, 09-375-6905, darrell.herling@pnl.
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5. **Date Project Initiated:** March 31, 2004

6. **Expected Completion Date:** February 28, 2007

PROJECT RATIONALE AND STRATEGY

7. **Project Objective:** The project will develop, test and implement functionally graded materials for hot forming operations in the forging, die casting and glass industries. The overall goal is to develop materials for tools, dies and processing equipment that significantly reduces energy usage and manufacturing costs.

8. **Technical Barrier(s) Being Addressed:** Project technical barriers are associated with the lack of current materials that can withstand the high temperature, stress, corrosive and erosive environment of many hot forming applications. Current issues include low strength at elevated temperatures, thermal cracking and fatigue, high energy and life cycle costs and poor erosion properties. Solving these barriers requires a new approach to materials selection and the manufacturing of these materials with advanced powder metallurgy technology.

9. **Project Pathway:** Two advanced powder metallurgy forming processes will be used to develop functionally graded materials (FGM) to meet the rigorous environment of many hot forming applications and significantly reduce energy usage and manufacturing costs. This goal will be accomplished by addressing current material issues with project partners from the forging, die casting and glass industries. Materials for tools and processing equipment will be custom designed and manufactured for testing in a commercial environment. Performance, energy usage and economics will be analyzed to determine which materials and fabrication process will be implemented by the project industrial partners.

10. **Critical Technical Metrics:** Materials currently used for tools, dies and other processing equipment in hot forming operations have been in existence for over fifty years. The cost of energy used is high and production efficiency low because of the inadequacies of these materials. The targets for success in this project is to reduce energy consumption by 25 percent and increase tooling lives by a minimum of five times that of current materials in these hot forming applications.

PROJECT PLANS AND PROGRESS

11. **Past Accomplishments:** Not applicable, project initiated in FY'04.

12. **Future Plans**:

    1. Review tooling issues and problems associated with the forging, die casting and glass forming industries. Planned completion 8/31/04.
    2. Identify functionally graded material (FGM) metallurgical systems that address high temperature strength, wear, metal reactivity, erosion and thermal management problems in a variety of applications. Planned completion 12/31/04.
    3. Model hot forging and die casting metal forming operations that address process requirements and key tool material problems. Planned completion 12/31/04.
    4. Model glass press forming operations to define materials requirements that address thermal management, glass reactivity with tooling and mold sticking problems. Planned completion 3/31/05.
    5. Utilize Laser Process Deposition (LPD) to produce tool and die FGM materials, develop a material property and microstructural database and optimize materials for manufacturing trials. Planned completion 8/31/05.
    6. Optimize key solid state dynamic process (Dynaforge) variables for manufacturing powder metallurgy FGM materials. Planned completion 8/31/05.
    7. Develop experimental FGM compositions and establish a mechanical property and microstructural database for Dynaforged powder metallurgy materials. Planned completion 12/31/05.
    8. Establish reproducibility and robustness of LPD and Dynaforge processes by defining optimum processing envelopes, property consistency, size capabilities and machining characteristics of FGM materials. Planned completion 6/30/06.
    9. Manufacture prototype tools for testing trials from selected FGM compositions using optimized LPD and Dynaforged processes for advanced commercial testing and tool performance evaluation. Planned completion 12/31/06.
    10. Assess performance, reduced energy usage and economic viability of FGM manufactured materials and implement for appropriate industrial applications. Planned completion 2/28/07.

13. **Project Changes:** None

14. **Commercialization Potential, Plans, and Activities:**
The end use applications for the technology proposed in this project include tools, die and molds in hot forging metals, die casting molten metals and press forming molten glass. Current materials are a bottleneck to increasing the manufacturing efficiency in these applications. Current plans are to develop advanced tooling materials for hot forging automotive steel components, die casting aluminum and magnesium parts and molding glass television picture tubes. Two advanced powder metallurgy consolidation technologies will be used to manufacture FGM's which will be designed to meet requirements for (1) tooling for two of the largest producers of forged automotive parts in the world, (2) tooling for both a major manufacturer and user of die casting equipment and (3) molds for one of the largest television picture tube manufacturers in North America. It is expected that the tool and die materials and fabrication methods developed as part of this project will be applicable to other manufacturing sectors as well. The technology will be implemented by committed project participants and disseminated throughout the U.S. industry as proven technology for reducing energy consumption and reducing manufacturing costs.

15. **Patents, Publications, Presentations:** None to date.